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ABSTRACT

To explore the relationships between factor analytic data reduction procedures and the Delphi iterative procedure for achieving consensus, a random sample of members of the National Association for Research in Science Teaching developed descriptions of teacher competencies for secondary science teachers. Following a sorting of the statements by content, the subjects assigned taxonomic levels to the content, according to Bloom's Taxonomy. This data was subjected to both factor analytic and ranking procedures to isolate a reduced set of descriptors. The two techniques produced highly similar descriptors which differed in regard to number, specificity, and relative importance of similar constructs. The resulting lists of teaching skills are appended. (Author/MV)

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Two Delphi Based Approaches to the Establishment of Valid Competencies for Teachers: Ranking and Factor Analysis

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Two Delphi Based Approaches to the Establishment of Valid Competencies for Teachers: Ranking and Factor Analysis

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To explore the relationships between factor analytic data reduction procedures and the Delphi iterative procedure for achieving consensus, a random sample of members of the National Association for Research in Science Teaching developed descriptions of secondary science teachers. Following a sorting of the statements by content, the subjects assigned taxnomic levels to the content. This data was subjected to both factor analytic and ranking procedures to isolate a reduced set of descriptors. The two techniques produced highly similar descriptors which differed in regard to number, specificity, and relative importance of similar constructs.

Two Delphi Based Approaches to the Establishment of Valid Competencies for Teachers: Ranking and Factor Analysis

Every curriculum developer faces the problem of developing a set of predicted outcomes of his planned activities which are acceptable to the target population. The idea that such a definition of predicted outcomes are essential is a given, how to obtain them is not. Several procedures have been used to obtain teacher competencies, e.g., soliciting practitioners perceptions, using conceptual models, conducting task analyses, and/or surveying the needs of the learner (Houston, 1975). However, regardless of the method employed, the curriculum developer is frequently left with a compilation of meaningless behavioral statements (Kay, 1975; Popham, 1971). To obtain a set of statements which are representative of the source's set of psychological constructs related to teacher education, it is necessary to both collect data from a sufficient number of sources to assure generalizability and to treat the data in a manner which isolates the constructs.

The Delphi is a technique that is used to clarify issues and to find solutions to problems which lack a theoretical foundation as a basis for attack but urgently need resolution in the near future (Helmer, 1967). In application of the Delphi procedure the perceptions of experts are iteratively processed to the end of either consensus or of polarization of views, thereby isolating the issues. Although originally developed as a forecasting tool (Rescher, 1967) its more promising educational

application seems to be a planning tool which may aid in probing priorities held by members and constituencies of an organization (Weaver, 1972).

Factor analytic teahniques provide the researcher with a means by which constructs may be isolated in a group of variables (Nunally, 1967). It is possible to use appropriate factor analytic procedures to find the underlying commonality among the variables, thus allowing their reduction to a smaller set of "factors" or "components" that may be assumed to be source variables accounting for observed interrelations in the data. The factors thus defined are based upon their commonality with each of the other variables considered. Such a factor is assumed to represent a psychological construct held commonly by those individuals responding to the variables.

Both the Delphi technique and factor analytic procedures are based on a Lockean model of the inquiry process (Linstone & Turoff, 1975). They presume that the truth of any system is associated entirely with its empirical content. The truth of a model of any system is presumed to be measured by the researcher's ability to reduce the complex phenomenon under consideration to simple (observational) referents and insure the model's validity through the establishment of its generalizability across different human observers.

Due in large measure to the conceptual and procedural similarity between the iterative "monitored" rounds of the Delphi and the iterative "consensus" processes employed in factory analysis, the researcher chose to determine to what extent similar results would be found using both procedures on a common set of data.

Population

The science educators selected for the specification of competencies for secondary science teachers were the members of the National Association for Research in Science Teaching (NARST). There are over 600 members listed in the NARST directory. The population consists mostly of College and University professors throughout the Unites States. Three random samples of 100 NARST members were selected to participate in the research.

Method

The research was initiated as a three-round Delphi survey. Round one consisted of a generalized charge which asked the question: What are the competencies (knowledge, skills, and attitudes) that all secondary science teachers (grades 7-12) should possess?

All responses to the question were duplicated and given to a panel of five individuals. Two of the panel members were science educators, and three were science teachers working on their doctorate in science education. The

judges independently sorted all responses into categories on the basis of content similarity (e.g., competencies regarding scientific method, inquiry, and scientific thinking being in a common category). The content areas were subsequently classified by the raters as being predominately related to cognitive, affective, and personality development.

Those categories of responses which were related to the cognitive domain comprised the item stems of the round two instrument. To ascertain the teacher competencies which science educators feel are of primary importance, it was deemed necessary to ascertain both the content and level of cognitive complexity for each competency statement. While the initial round of the Delphi provided a sample of the content percieved as relevant to science educators, the level of cognitive development required by each competency statement submitted, reflected the possibility unique view of the particular science educator who suggested the competency. In round two, however, the science educators were instructed to indicate at what level along Bloom's Taxonomy of Cognitive Objectives (knowledge, comprehension, application, analysis, synthesis, and evaluation) they felt secondary science teachers should be able to demonstrate a given behavior.

To this stage the procedures for both of the analytic processes were the same. As figure 1 illustrates, the data from the second round of the Delphi study was treated differently for each analysis. In the instance of the Delphi a third round of data was required to reach consensus.

Insert figure 1 about here

To complete the Delphi analysis, a one sample chi square test was used to identify indicators with taxonomic levels that were consistently chosen by the science educators. Indicators with significant ($p \leq .05$) chi square values were analyzed to determine which taxonomic level had the highest response frequency. Competencies were then written at the specified level and reviewed by three colleagues to assure that they could be identified as being representative of a particular taxonomic level.

The third instrument used for the Delphi listed the competencies. Each competency consisted of a competency statement and one or more competency indicators. This instrument was sent to a random sample of NARST members to rank the competencies in the order of their perceived importance.

To complete the Factor analytic Delphi, data from the second round of the Delphi was used in an iterative principal component factor analysis in which a varimax rotation was used to maximize statistical independence of the resultant factors. An eigenvalue of ≥ 1 was used for inclusion of the factors and all variables which loaded $\geq .40$ were used in the interpretation of the factors.

Results

Round one of the Delphi resulted in more than two hundred statements which were judged to fall into 15 distinct categories or "competencies" with two

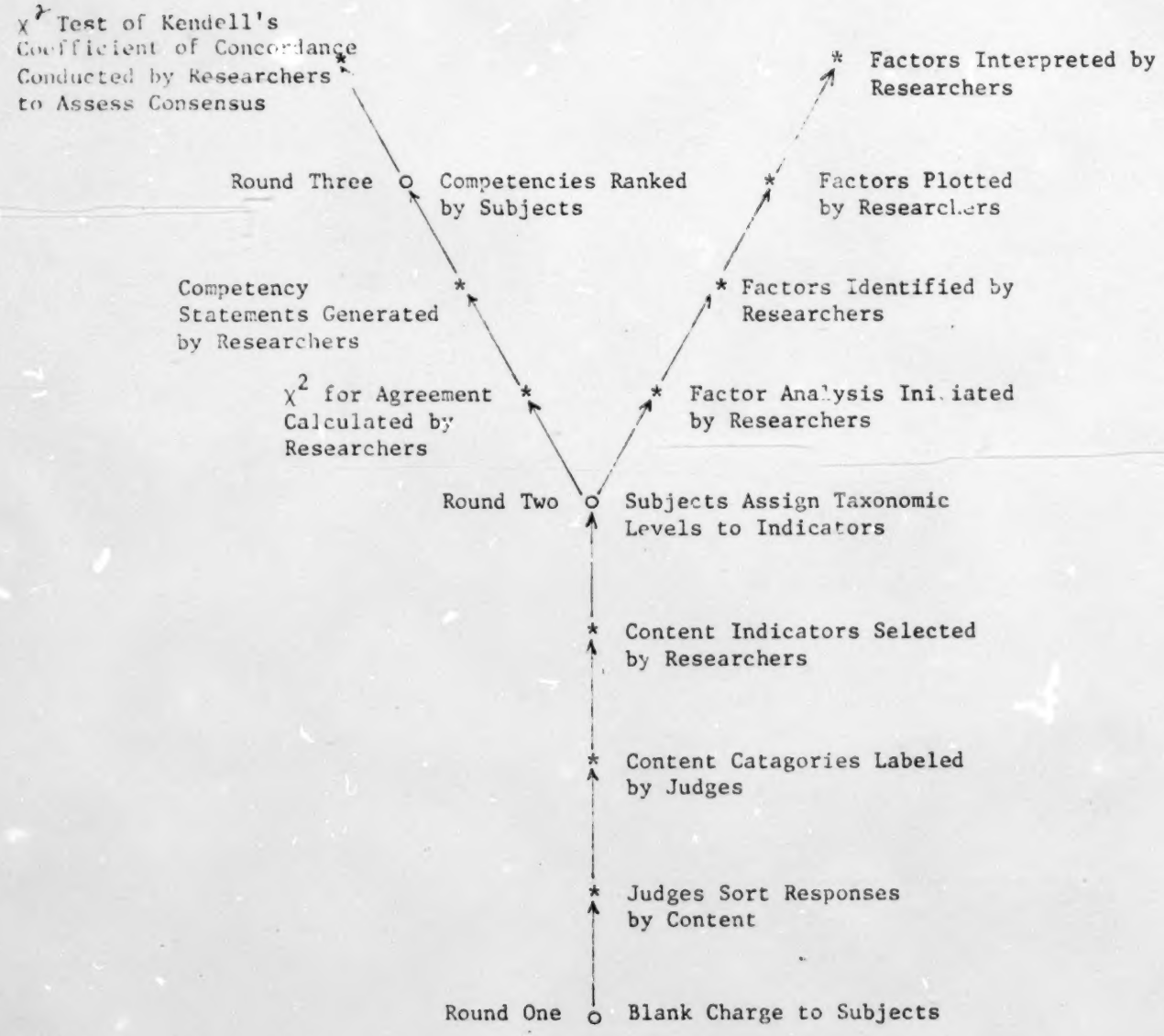
χ^2 Test of Kendell's Coefficient of Concordance Conducted by Researchers to Assess Consensus
Factors Interpreted by Researchers
Round Three
Competencies Ranked by Subjects
Factors Plotted by Researchers
Competency Statements Generated by Researchers
Factors Identified by Researchers
χ^2 for Agreement Calculated by Researchers
Factor Analysis Initiated by Researchers
Round Two
Subjects Assign Taxonomic Levels to Indicators
Content Indicators Selected by Researchers
Content Catagories Labeled by Judges
Judges Sort Responses by Content
Round One
Blank Charge to Subjects

FIGURE I. Procedures Followed In The Study

or more indicators under each. Within round two of the Delphi analysis 35 of the 39 categorized indicators evidenced sufficient consistency (χ^2 sig @ $p \leq .05$) to remain in the analysis. The resultant 15 competency statements were ranked by the subjects. Their summated ranking is shown in Table 1. To establish the degree of consensus of the ranking a Kendall coefficient of concordance (W) was calculated and tested for significance using the chi-square distribution, significance at the $p \leq .001$ level was found.

Insert Table 1 about here

The factor analysis of the round two data resulted in the identification of nine factors with eigenvalues ≥ 1. These factors summarized in Table 2 accounted for 90.6% of the variance in the taxonomical rating of the behavioral statements. The factors were subsequently plotted to provide a clearer view of their interrelationship thus facilitating interpretation.

Insert Table 2 about here

The two techniques have provided two sets of perceptions of the secondary science teacher's attributes as viewed by science educators. While they are highly similar they are not identical. The rating based Delphi resulted in more specific content statements than the factor analytic procedure. This is probably attributable to the fact that initial categorization was based upon the sample's responses in the factor analytic analysis.

TABLE I

RANKING OF 15 COGNITIVE COMPETENCIES

Competencies	Summated Ranking*	Mean Ranking	Rank Order
PROVIDES FOR A HUMANLY SUPPORTIVE ENVIRONMENT	255	4.90	1
PLANS AND ORGANIZES INSTRUCTION	274	5.26	2
POSSESSES A SOUND SUBJECT MATTER BACKGROUND	283	5.44	3
RELATES PSYCHOLOGICAL DEVELOPMENT WITH LEARNING SCI. SUBJECT MATTER	344	6.62	4
DEMONSTRATES THE ABILITY TO COMMUNICATE EFFECTIVELY	350	6.73	5
INCORPORATES EFFECTIVE LABORATORY ACTIVITIES INTO INSTRUCTION	380	7.31	6
TEACHES SCIENCE VIA THE INQUIRY, PROCESS AND DISCOVERY APPROACH	383	7.37	7
DEMONSTRATES THE USE OF A VARIETY OF INSTRUCTIONAL STRATEGIES AND TECHNIQUES	400	7.69	8
PROVIDES FOR INDIVIDUAL DIFFERENCES	413	7.94	9
EMPLOYS EVALUATION SKILLS AND PROCEDURES	432	8.31	10
EMPLOYS EFFECTIVE CLASSROOM MANAGEMENT TECHNIQUES	451	8.67	11
RELATES SCIENCE TO SOCIETY	464	8.92	12
POSSESSES A KNOWLEDGE OF THE HISTORY AND PHILOSOPHY OF SCIENCE AND ITS SOCIAL IMPLICATIONS	545	10.48	13
POSSESSES A BACKGROUND IN MATHEMATICS	604	11.62	14
KNOWLEDGEABLE ABOUT VARIOUS SCIENCE CURRICULA	619	11.90	15

* Based upon the rankings of 15 competencies by 52 science educators

TABLE II. Primary Factors

Factor		Eingenvalue	% Variance Accounted For
1	Background Preparation in the Sciences	7.42	27.3
2	Classroom Organization and Management Skills	3.88	14.3
3	Lesson Activity Skills and Strategies	3.52	13.0
4	Professional Sensitivity toward Students and Colleagues	2.18	8.0
5	Humane Control of the Students	1.97	7.3
6	Diagnosis of Learning Difficulties of Students	1.76	6.5
7	Understanding the Psychological Effects of Instruction	1.51	5.6
8	Ability to Prepare Instruction Based on Reality	1.35	5.0
9	Ability to Facilitate Interactive Learning Activities	1.00	

Conclusions

Each procedure provides a valid reduction of data and presents it in a form which could be readily used to prepare secondary science teachers. However, the nature of the behavioral statements differs in each instance. The factor analytic procedure defines the constructs which comprise secondary science teaching in the minds of the sample population. The ranking produces similar statements but they more directly influenced by the rater's perception of the world of teaching as he knows it. Thus, while a factor such as knowledge of subject matter may be most central to the construct secondary science teacher, when asked to rank that factor with others the subject may give higher priority to a factor such as humanistic education which he feels is more needed by those who teach in his discipline.

In the light of the factor analytic procedure's ability to reduce greatly the number of variables under consideration without taxing the subjects, it is recommended as a second round procedure in the Delphi. Were it to be combined with a third round ranking of the factors it should provide the curriculum developer with a thorough and accurate set of behavioral statements representing both the psychological constructs and perceived priorities of the subjects.

Biblography

Helmer, O. New Developments in Early Forecasting of Public Problems: A New Intellectual Climate, RAND Document P-3576, April, 1967.

Houston, R. (Ed.) Competency Assessment Research and Evaluation. Albany, New York: American Association of Colleges for Teacher Education, 1975.

Kay, P. What Competencies Should be Included in a C/PBTE Program? Washington: American Association of Colleges for Teacher Education, May, 1975.

Linstone, H. & Turoff, M. The Delphi Method: Techniques and Applications. Reading, Mass.: Addison-Wesley, 1975.

Nunnally, J. Psychometric Theory. New York: McGraw-Hill, 1967.

Pophan, W. J. Performance tests of teaching proficiency: Rationale, development, and validation. American Educational Research Journal, 1971, 8, 105-117

Rescher, N. The Future as an Object of Research. RAND Document P-3593, April, 1967.

Weaver, T. Delphi Forecasting Method: Some Theoretical Considerations. In Zeigler & Marien (eds.) The Potential of Educational Futures. Worthington, Ohio: Charles A. Jones, 1972.